A successful feeding system to reach peak milk can be defined as delivering the needed nutrients to each cow to meet her requirements as economically as possible. Stage of gestation and lactation will determine nutrient requirements and feeding system strategies. Four factors can impact dairy cow nutrient requirements. Each factor has a pattern as the cow progress through the lactation and gestation cycle.

**PHYSIOLOGICAL CURVES**

*Milk Production Curve.*

Milk production drives nutrient needs for dairy cows. Peak milk set the lactation curve for cows and should occur 40 to 60 days after calving. First lactation cows should reach 75 percent or greater peak milk levels compared to peak milk of mature cows in the herd. For example, if first lactation cows averaged 30 kg of peak milk while mature cows averaged 40 kg of peak milk, the ratio is 75 percent (30 kg divided by 40 kg times 100). If the ratio is less than 75 percent, first lactation cows are not peaking high enough compared to mature cows. If first lactation cows peak over 75 percent of mature cows, heifers are peaking higher due to improved genetics, health, and/or heifer rearing programs or mature cows are not peaking high enough due to health or management limitations.

*Milk Fat and Milk Protein Curve*

Milk fat and protein levels will vary by breed. If milk fat test is below milk protein test by 0.4 of a percentage point or more (for example 2.7 percent milk fat and 3.2 percent milk protein), rumen acidosis can be occurring. If milk protein test is below breed average or drops during lactation, the following nutritional causes lower milk protein could be occurring.
- Low levels of fermentable carbohydrate (lowers microbial protein synthesis)
- Low levels of dry matter intake (reduces the supply of nutrients available for the rumen microbes and cow)
- Protein shortage and/or imbalance of amino acids
- Use of fats and oils as energy sources (fat is not a source of rumen fermentable energy)

**Dry Matter Intake Curve**

Increasing dry matter intake can minimize metabolic disorders, minimize weight loss, and improve reproductive performance. During late gestation, dry matter intake can decline 2 to 4 kg. Wisconsin workers concluded that dry matter intake at calving impacted dry matter intake four weeks postpartum. If dry matter is lower than predicted, the nutrient concentration must be increased to meet the cow's nutrient requirements. After calving, dry matter intake slowly increases (Table 1).

Table 1. Estimated dry matter intake for first lactation (545 kg) and mature (636 kg) cows for the initial five weeks postpartum.

<table>
<thead>
<tr>
<th>Week</th>
<th>First lactation cows</th>
<th>Mature cows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>---------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>1</td>
<td>14.1</td>
<td>16.6</td>
</tr>
<tr>
<td>2</td>
<td>15.9</td>
<td>19.3</td>
</tr>
<tr>
<td>3</td>
<td>17.3</td>
<td>21.1</td>
</tr>
<tr>
<td>4</td>
<td>18.2</td>
<td>22.3</td>
</tr>
<tr>
<td>5</td>
<td>18.9</td>
<td>23.9</td>
</tr>
</tbody>
</table>

Dry matter intake for first lactation cows is less than mature cows that must be considered when grain is fed independent of forages, especially in component fed herds. Guidelines for dry matter intake for various phases are listed in Table 2.
**Body Weight Loss and Gain Curve**

Monitoring weight changes provide valuable information on energy status of cows. High producing cows will lose weight to support high energy needed in early lactation. Body condition scoring (BCS) is a field method to monitor weight changes. The following guidelines can be used to evaluate weight changes.

- One BCS (using the 1 to 5 system) is equal to 55 kg of body weight.
- Cows should not lose more than 1 to 1.5 BCS points (55 to 80 kg of weight) in early lactation.
- Weight loss should be limited to 1 kg per day in early lactation avoid negative effects on reproduction and cause metabolic disorders.
- Cow should be at the optimum BCS prior to drying off (3.25 to 3.75). If dry cows are thin, limit weight gain to one half body condition score (for example, shifting dry cows from 2.75 to 3.25) which represents 30 kilograms or 0.45 kilogram of weight gain per day during the dry period.

By evaluating the four factors during the lactation and gestation cycles in dairy cows, six feeding phases or rations can be developed (Table 2). On some farms, fewer groups of cows may be needed to meet nutrient needs.

**TRANSITION FEEDING APPROACHES**

Close-up dry cow phase starts 21 days prepartum to calving. If this period is less 10 days, 24 percent of the dry cows will have not receive the phase two ration for the minimum five days needed to achieve desired benefits. Iowa workers identified four physiological goals that the close up dry cow program must achieve.

1. Adapt the rumen for higher energy diets fed postpartum
2. Maintain normal blood calcium levels
3. Build and stimulate the immune system
4. Maintain a positive energy balance to avoid fatty acid infiltration and sub-clinical ketosis

Increasing the level of grain shifts rumen microbes that can ferment high-energy diets and stimulate rumen papillae to elongate increasing papillae surface area. Energy balance can be negative for several reasons.

- Dry matter intake may drop 15 to 30 percent before calving.
- The unborn calf is rapidly growing requiring more nutrients.
- Cows with twin pregnancy have lower DMI, earlier decline in DMI, and a great conceptus mass.
- Formation of colostrum and mammary tissue regeneration.
Body weight loss can be occurring and ketosis risk increased due to fat mobilization. Non-esterified fatty acids (NEFA) originate almost entirely from mobilized fatty. Diet fatty acids are transported as triglycerides and phospholipids. The presence of NEFA in plasma above normal (>0.3 mEq/l) indicates that fat is being mobilized in response to negative energy balance. Plasma NEFA begin increasing 3 to 10 days prepartum, peaking at calving (0.5 to 0.8 mEq/l), and declining postpartum (< 0.6 mEq/l) in healthy cows. Table 2 provides nutrient guidelines for phase two. Management strategies during the close up dry period (phase two) are listed below.

- Increase grain to 2 to 4 kg of dry matter
- Increase crude protein to 14 to 15 percent using rumen undegraded protein (RUP) sources or greater than 1000 g of metabolizable protein
- Limit added fat to 150 grams per day
- Maintain 4 to 6 kg of long forage (hay, long hay silage, and/or straw)
- Consider feeding 3 to 5 kg DM from the high group TMR (contains UIP, fat, grain, and higher quality forages) plus the phase two grain mix and long forage
- Reduce and restrict supplemental sodium
- Add anionic salts or compounds to prevent low blood calcium
- Add yeast culture (10 to 120 grams per day depend on the product selected)
- Add niacin (3 grams per day of rumen protected choline)
- Drench with propylene glycol (225 grams) starting 3 to 5 days before calving or feed calcium propionate (180 grams) if sub-clinical ketosis is occurring

The fresh cow phase begins at calving to 2 to 3 weeks after calving. The key management factor is the ability to monitor and observe these cows to insure they are healthy when moved to the high group and are challenged with higher nutrient dense diets. Individual cow management occurs in this phase requiring headlock or tie stalls. The following evaluations should be recorded each day to assess the cow's status.

1. Monitor feed intake by evaluating how the cow consumes or "attacks" fresh feed. Record the amount or develop a scoring system (1 = 0 to 33 percent consumed, 2 = 33 to 66 percent consumed, 3 = 66 to 99 percent consumed, and 4 = all consumed).
2. Record daily body temperatures until temperatures drop under 39 degrees C (102.5 degree F).
3. Listen for rumen movements with a stethoscope (cows should have 1 to 2 rumen movements per minute).
4. Observe uterine discharges for odors and characteristics.
5. Conduct a ketone test on the cow's urine or milk to access energy status.
The fresh cow ration should be intermediate between the close up ration and the high group. Wisconsin workers suggest a change in a ration should not greater than 10 percent increase in a nutrient (for example, changing from 1.54 NE-lactation by 10 percent would be 0.15 unit shift in the next ration or a 1.69 Mcal NE-l per kg). Maintain a "healthy" level of fiber and avoid high starch levels leading to off feed risks. Table 7 lists recommended nutrient levels for this phase. The following strategies can be considered for fresh cow phase 3.

- Feed 1 to 3 kg of high quality long forage to maintain rumen function
- Consider a fresh cow top dress mixture that contains rumen undegraded protein and digestible fiber (such as soy hulls or citrus pulp) as an energy source
- Increase the ration nutrient concentration to adjust for lower feed intakes
- Supplement yeast culture to stimulate fiber digesting bacteria
- Adding a buffer pack can stabilize rumen pH
- Drench propylene glycol (225 grams) or calcium propionate (180 grams) to raise blood glucose

Table 2 contains nutrient guidelines for a phase feeding system. Values have been adjusted to allow for modest nutrient increases (up 10 percent) and decreases (down 5 percent) between groups to avoid digestive disorders and large declines in milk production. All vitamins listed are supplemental amounts from commercial feed sources (unless cows are on pasture systems). Trace minerals amounts include basal feed ingredients and added levels from commercial feed supplements. Non-fiber carbohydrate (NFC) values were calculated using the following formula: 
NFC = 100 - (% crude protein + % NDF + % ash + % ether extract).
Table 2. Illinois nutrient recommendations for dairy cows in different stages of lactation and gestation.

<table>
<thead>
<tr>
<th></th>
<th>Dry Cow</th>
<th>Fresh 0 to 21d</th>
<th>Early 22 to 80d</th>
<th>Milk Cows Middle 80 to 200d</th>
<th>Late &gt;200d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early</td>
<td>Close-up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMI (lbs)</td>
<td>30</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude Protein (CP) %</td>
<td>12</td>
<td>Cows 12 – 13</td>
<td>19</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>Metabolizable Protein (%)</td>
<td>6.0</td>
<td>8.0</td>
<td>13.8</td>
<td>11.6</td>
<td>10.2</td>
</tr>
<tr>
<td>*RDP: % of CP (DM)</td>
<td>70 (8.4)</td>
<td>60 (10)</td>
<td>60 (11.4)</td>
<td>62 (11.2)</td>
<td>64 (10.2)</td>
</tr>
<tr>
<td>RUP: % of CP (DM)</td>
<td>30 (3.6)</td>
<td>40 (5)</td>
<td>40 (7.6)</td>
<td>38 (6.8)</td>
<td>36 (5.8)</td>
</tr>
<tr>
<td>SIP: % of CP (DM)</td>
<td>35 (4.2)</td>
<td>30 (4.5)</td>
<td>30 (5.7)</td>
<td>31 (5.6)</td>
<td>32 (5.10)</td>
</tr>
<tr>
<td>TDN %</td>
<td>60</td>
<td>67</td>
<td>75</td>
<td>77</td>
<td>75</td>
</tr>
<tr>
<td>NEEL (Mcal/lb)</td>
<td>0.63</td>
<td>0.69</td>
<td>0.78</td>
<td>0.80</td>
<td>0.78</td>
</tr>
<tr>
<td>Ether Extract %</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5.5</td>
<td>5</td>
</tr>
<tr>
<td>ADF %</td>
<td>30</td>
<td>24</td>
<td>21</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td>NDF %</td>
<td>40</td>
<td>35</td>
<td>30</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>*NFC %</td>
<td>30</td>
<td>34</td>
<td>35</td>
<td>38</td>
<td>36</td>
</tr>
</tbody>
</table>

*Ratio of NFC to DIP (% of DM) = 3.5:1

Major Minerals in % of DM

<table>
<thead>
<tr>
<th></th>
<th>Calcium (Ca)</th>
<th>Phosphorous (P)</th>
<th>Magnesium (Mg)</th>
<th>Potassium (K)</th>
<th>Sodium (Na)</th>
<th>Chlorine (Cl)</th>
<th>Sulfur (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>0.60</td>
<td>0.26</td>
<td>0.16</td>
<td>0.65</td>
<td>0.10</td>
<td>0.15</td>
<td>0.16</td>
</tr>
<tr>
<td>Close-up</td>
<td>0.7 (*1.0)</td>
<td>0.30</td>
<td>0.3 (*0.4)</td>
<td>0.65</td>
<td>0.05</td>
<td>0.15 (*0.8)</td>
<td>0.2 (*0.4)</td>
</tr>
<tr>
<td>Fresh 0 to 21d</td>
<td>1.0</td>
<td>0.40</td>
<td>0.33</td>
<td>1.00</td>
<td>0.33</td>
<td>0.30</td>
<td>0.25</td>
</tr>
<tr>
<td>Early 22 to 80d</td>
<td>0.90</td>
<td>0.38</td>
<td>0.30</td>
<td>1.00</td>
<td>0.30</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Milk Cows Middle 80 to 200d</td>
<td>0.70</td>
<td>0.36</td>
<td>0.25</td>
<td>0.90</td>
<td>0.20</td>
<td>0.25</td>
<td>0.22</td>
</tr>
<tr>
<td>Late &gt;200d</td>
<td>0.60</td>
<td>0.32</td>
<td>0.20</td>
<td>0.90</td>
<td>0.20</td>
<td>0.25</td>
<td>0.25</td>
</tr>
</tbody>
</table>

*When anionic salts are used: mineral/anionic salts (%)

Vitamins in IU per Day

<table>
<thead>
<tr>
<th></th>
<th>Vitamin A</th>
<th>Vitamin D</th>
<th>Vitamin E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>100,000</td>
<td>25,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Close-up</td>
<td>100,000</td>
<td>30,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Fresh 0 to 21d</td>
<td>100,000</td>
<td>30,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Early 22 to 80d</td>
<td>100,000</td>
<td>25,000</td>
<td>800</td>
</tr>
<tr>
<td>Milk Cows Middle 80 to 200d</td>
<td>50,000</td>
<td>20,000</td>
<td>600</td>
</tr>
<tr>
<td>Late &gt;200d</td>
<td>50,000</td>
<td>20,000</td>
<td>400</td>
</tr>
</tbody>
</table>

*Trace minerals: iron (150 ppm), cobalt (0.1 ppm), copper (15 ppm), manganese (60 ppm), zinc (60 ppm), iodine (0.6 ppm), and selenium (0.3 ppm).